Modeling the Cities:

The Los Alamos Urban Security Initiative

1998 Annual Report

The Problem: All cities, regardless of size, have a unique set of problems related to security, energy, water, nutrition, economics, and the environment. An understanding of these problems allows us to better evaluate vulnerabilities related to the hazards of natural events such as a hurricane or the unnatural event of a terrorist attack. With the future of the nation and the planet at stake, we must develop the tools necessary for urban survival.

The Response: For cities to be safe and sustainable, we must implement long-range urban planning and risk assessment tools and not rely on reactive decision making. The tools must be based on an accurate assessment of the inter-relationships among the many complex processes that occur in the urban environment.

The Approach: To understand urban systems demands multidisciplinary approaches that account for physical processes, economic and social factors, and nonlinear feedback across a broad range of scales and disparate process phenomena. Strong research programs in the defense, environmental, and computational arenas at Los Alamos have developed many state-of-the-art models that will serve as components of an urban modeling system. These include programs in transportation, air quality, groundwater transport, energy distribution, network theory, communications, synthetic population modeling, natural hazards, and risk assessment. We are building on these and other modeling tools, modifying them for urban settings, and linking them together as an integrated simulation system that takes advantage of our high performance computing (HPC) platforms. We are engaging collaborators from the urban planning community and university campuses to ensure relevance and to eliminate "wheel reinventing."

The Los Alamos Urban Security Team includes environmental engineers, geologists, software designers, natural hazard specialists, mathematicians, hydrologists, civil engineers, atmospheric scientists, chemists, geographic information system specialists and transportation experts who work in collaboration with urban planners and environmental scientists from academia and the government. We are using high-performance computing platforms to adapt existing in-house process-oriented models and to develop new models that interact in an integrated system. The goal is a scientific competency in urban systems and an ability to simulate the dynamic and complex cities of today and the next millennium.

"Mankind's future will unfold largely in urban settings."

—Mega-City Growth and the Future (Fuchs et al, 1994)

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Why Should The Los Alamos National Laboratory Study Urban Systems?

It is widely recognized that short- and long-term national security depends upon a judicious balance of investment in defense, economic, social, educational, and environmental programs. The vitality of our national infrastructure, which overlaps and merges with the aforementioned programs, is therefore critical to our national security. We believe that our nation is most vulnerable where the infrastructure elements converge—in the cities. Supporting this belief is the recent Presidential Decision Directive to the US Government to protect the Nation's critical infrastructure.

Our vision for the Los Alamos National Laboratory is to develop a cross-divisional applied research competency to model the vulnerability and response of urban systems to changes in physical environment, malicious attacks, social-political setting, and the economy.

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URBAN SECURITY ACTIVITIES

To effectively develop the competency in urban security, we have divided the project into seven areas: (1) urban air-water transport pathways, (2) earthquakes and urban infrastructure, (3) city recovery and growth, (4) airborne toxic release/traffic exposure[1], (5) linked atmospheric and hydrologic modeling[1], (6) framework design, and (7) geographic information systems. The long-term goal is to link these areas and others as a "system of systems." Some crossover between components is already occurring within the CD— for example, researchers in urban air-water transport pathways are talking to researchers in earthquakes and urban infrastructure about simulating the fate and transport of fluids from earthquake-damaged hazardous chemical storage areas in Los Angeles. The team simulating city growth will be working with the earthquake and infrastructure team to look at models of the growth of Los Angeles following an earthquake. The teams developing the architecture framework and the geographic information systems are working with all of the other teams. After a year and a half, we are well on the way to developing a strong Laboratory competency to look at the vulnerability of urban systems via inter-disciplinary research that uses tera-flop scale computing capability.

"The deepening threat... is the terrorist use of nuclear, biological, and chemical weapons to inflict mass urban casualties and social paralysis almost anywhere in the world"

Aviation Week and Space Technology, June 17, 1996

All of the teams are developing components that will provide research underpinnings of new Laboratory thrusts involving protection against chemical and biological attacks (Chemical/Biological Non-Proliferation; CBNP) and Critical Infrastructure Protection (CIP)—there is a symbiosis between Urban Security, CBNP, TRANSIMS and the Infrastructure Assurance and Analysis Project, all of which are based on state-of-the-art capabilities in simulation science.

Urban systems are composed of a wide range of subsystems: transportation, construction, energy distribution, communication, water, meteorological phenomena, geology, ecosystem, solid waste, food

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[1] Part of the 1997 project. During FY98 this work was spun off into other projects.

and water distribution, economic zones, and demographics, for example. We are linking the many components of an urban system, rooting our framework in sophisticated physical models and abstracting the essential physical, social, and economic interactions so that decision-makers can answer questions of importance on urban security

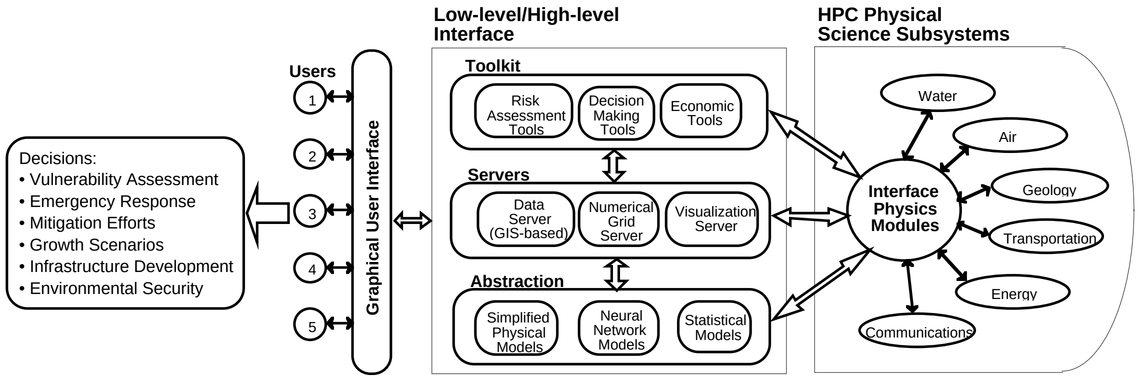


Figure 1. Schematic of proposed system architecture for answering urban security questions. Sophisticated numerical models from across disciplines and covering a broad range of scales will be integrated through interface physics modules. Methods for abstracting the “essential” physics will be utilized to speed computations and generalize results. Links between the physics-based models will be made to decision-making tools. Servers will provide data and visualization tools to the end-user.

(Fig. 1). We are modeling these subsystems in detail using state-of-the-art models developed within the Laboratory. A challenging aspect of this research effort is the understanding of the interfaces between the models (right hand side, Fig. 1). These subsystems are linked and their interaction produces the collective and often non-intuitive behavior of the urban system. This part of the framework demands high performance computing (HPC) since each subsystem alone can be an HPC-scale problem.

Our approach is to emphasize linking cross-disciplinary subsystem models, tailoring them for urban applications, and writing interface modules. We are accomplishing this with a portfolio of research topics that force tailoring and interfacing the subsystem models. Our early efforts have focused on the high-level/low-level interface (middle, Fig. 1) and later will shift toward decision-making tools (left hand side, Fig. 1). Below we review our accomplishments in the seven tasks described above.

Airborne Toxic Release/Traffic Exposure

Introduction. If a tanker truck carrying hazardous chemicals overturns in a city, could emergency response crews estimate the exposure to vehicles that unwittingly drove through the poisonous cloud? Or, if a terrorist releases a chemical or biological agent in the downtown area, could first responders figure out how the toxic agent spread, where it ended up, and how much was transported away from the scene by moving vehicles? Our team is linking together LANL-developed fluid dynamics models and traffic simulation codes and applying them to plume dispersion and vehicle exposure applications in the urban environment. These tools may help emergency response personnel answer some of the aforementioned questions. Our initial simulations have led to some interesting counter-intuitive results that we describe below.

Accomplishments during 1997 The goal of the Airborne Toxic Response/Traffic Exposure task was to demonstrate a capability for analyzing emergency response issues resulting from accidental or meditated airborne toxic releases in an urban setting. In the first year of the program, we linked a system of fluid dynamics and vehicle transportation models developed at Los Alamos to study the dispersion of a plume in an urban setting and the resulting exposures to vehicle traffic (Fig. 2). The HOTMAC prognostic mesoscale model computed three-dimensional meteorological fields over a domain of several hundred kilometers centered over Dallas, Texas. Zooming in to higher resolution using a nested grid computational mesh, the wind and turbulence fields computed on a 2 km grid size provided boundary conditions for a higher resolution simulation of flow around two 2-d buildings using the GASFLOW computational fluid dynamics code. A gas source was located at ground level between the two buildings and the near-source transport and dispersion of the

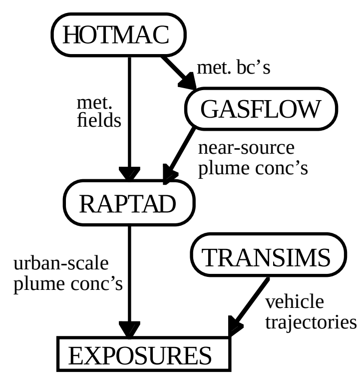


Figure 2. Flowchart showing the links between the mesoscale atmospheric model HOTMAC, the microscale fluid dynamics model GASFLOW, the Lagrangian dispersion model RAPTAD, and the TRANSIMS traffic simulation model.

contaminant cloud was simulated at several meter resolution using the GASFLOW model.

In order to evaluate the impact of the buildings on the larger-scale plume dispersion and transport, we ran one simulation accounting for the buildings and one without buildings. We found what we considered a strange result: in the same amount of time the plume traveled farther in the case when the buildings were accounted for (see Fig. 3). Initially, we expected the plume to travel a shorter distance for this case due to trapping of the plume between the buildings.

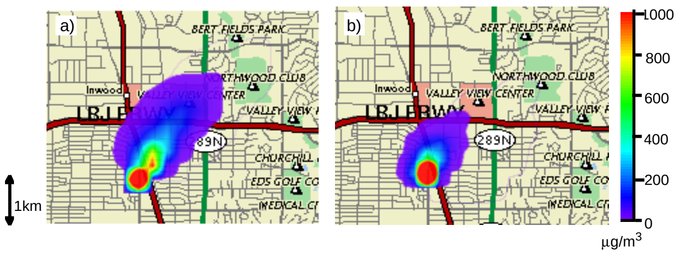


Figure 3. Comparison of GLC fields computed a) with the HOTMAC-RAPTAD and GASFLOW modeling systems and b) with the HOTMAC-RAPTAD modeling system only. This figure shows that explicit modeling of buildings significantly impacts plume transport and dispersion.

Although trapping does occur, a stronger competing process transpired: because of building-induced turbulent mixing, the plume was lofted higher in the air and was then carried by the higher speed winds aloft. Figure 4 shows the concentration contours computed around the two buildings. Due to recirculation and trapping between the two buildings, concentrations are highly elevated there. We also see that the cloud is lofted very high into the atmosphere downstream of the buildings, a condition of the enhanced turbulent mixing resulting from the building obstructions.

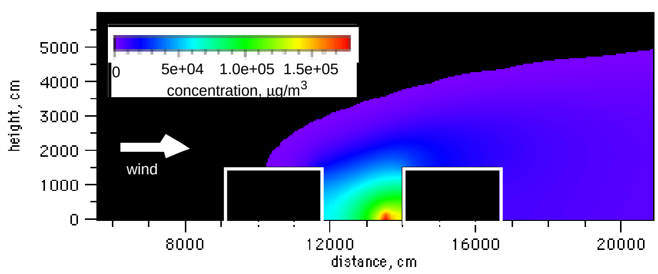


Figure 4. Concentration field computed by the GASFLOW model for a surface release in an urban canyon.

This has an important impact once the plume is passed from the microscale GASFLOW domain to the mesoscale HOTMAC/ RAPTAD domain. A paper entitled “The effect of microscale urban canyon flow on mesoscale puff dispersion” referenced in the Appendix gives more detail on this portion of the research.

A simulation performed by the TRANSIMS team computed traffic flow for over 100,000 vehicles in North Dallas. TRANSIMS represents a new approach in traffic modeling where the movement of individual cars is performed using cellular automata techniques. The interaction of the cars on the microscale results in macroscopic traffic patterns seen in common everyday traffic.

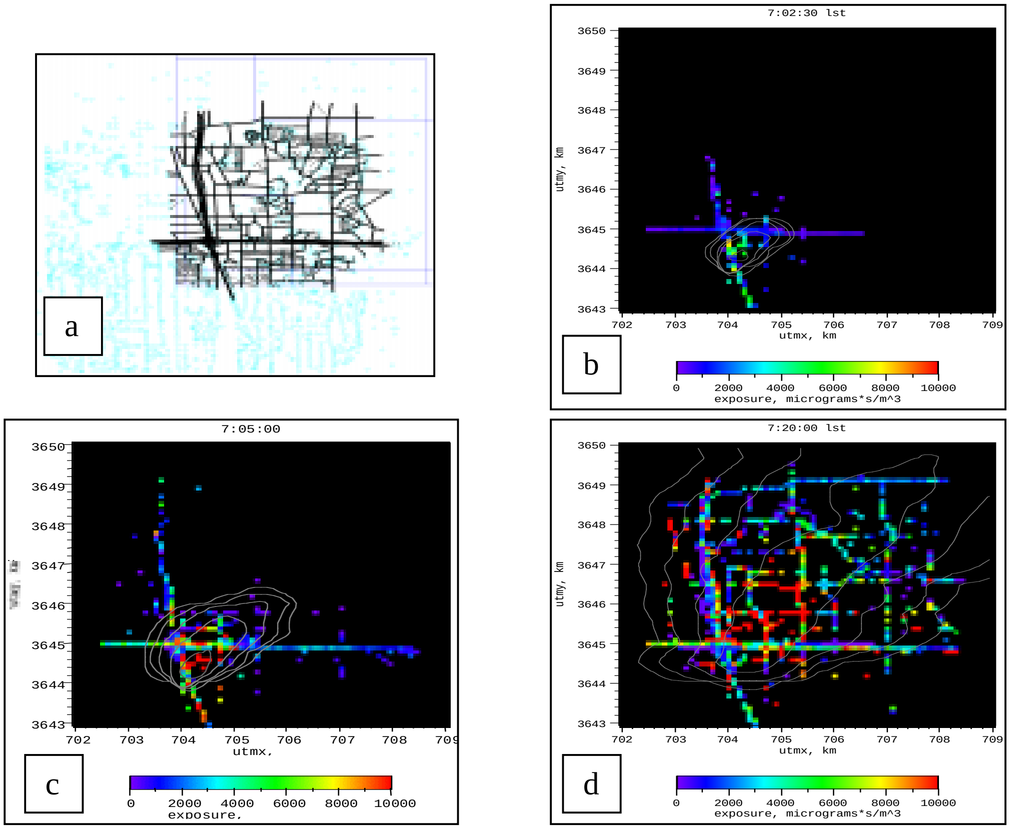


Figure 5. a) Major roadways impacted by the contaminant cloud. Diamonds represent intersection nodes and cover the entire active simulation region. Vehicle exposures and plume concentration contours depicted for b) 2.5 , c) 5, and d) 20 minutes after the release start time.

Figure 5a depicts the major roadways in the vicinity of the plume, along with the intersection nodes in the simulated domain.

Vehicle trajectory and plume concentration data were used to compute exposures to over 36,000 vehicles traveling through the time-varying contaminant cloud in the Dallas-Ft. Worth area. Fig. 5a depicts the major roadways in the vicinity of the plume, along with the intersection nodes in the simulated domain. The vehicle exposure plots shown in Figs. 5b, c, and d clearly delineate the major thoroughfares (the N. Dallas Tollway and the LBJ freeway) and show that the vehicles carry the toxic

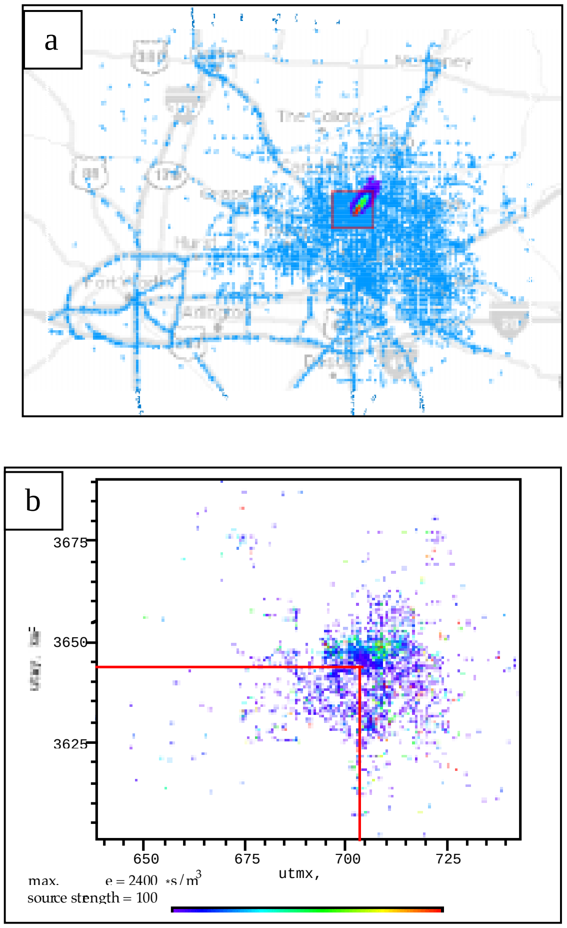


Figure 6. **a)** Node locations of the roadway network in the Dallas-Ft. Worth area. The spatial extent of the plume location 10 minutes after release is depicted. The red box demarcates the region of active traffic simulation. **b)** Vehicle exposure as function of final destination. Intersection of red lines denote contaminant plume source location.

agent away from the source location faster than the transport winds. The agent is transported by the vehicles over a much larger area than that covered by the plume (Fig. 6). Moreover, the final locations of vehicles with high exposure are not obvious.

Using a modeling system like this, emergency response personnel could determine the impact zones, the optimal routes for response teams, where casualties might occur, and how the agent is dispersed. The efforts of clean-up crews and medical teams could be enhanced as well with knowledge of the final location and levels of exposure. Further research efforts are underway at Los Alamos to better estimate the impact of multiple buildings on plume transport and dispersion. Research on transportation simulation continues at LANL, including efforts to abstract the fundamental vehicle flow dynamics so that problems can be run on PC platforms.

Accomplishments during 1998 This work was used to help market the Chemical-Biological Weapons Non-Proliferation project. The multi-scale modeling of plume transport and fate in urban environments is now ongoing in the CBNP project. A joint multi-million dollar proposal between LANL and the National Defense Universities is being pursued for building a real-time, immersive virtual environment for training decision-makers in crisis situations. Our work on the airborne toxic release/vehicle exposure task is being used as one of the demonstration projects in this proposal.

Urban Air-Water Transport Pathways (Urban Nitrate Cycle)

Introduction. We are attempting to simulate the transport of pollutants in an urban environment from source to sink. In order to follow the pollutants through the complete air and water pathway system, we must link cross-disciplinary subsystem models, tailor them for urban applications, and write interface modules. We are focusing on the transport and fate of nitrates because 1) they track through both the air and water pathways, 2) the physics, chemistry, and biology of the complete cycle are not well understood, 3) nitrates have important health, local ecosystem, and global climate implications, and 4) the problem requires us to stretch our capabilities in non-traditional areas, including several relating to urban infrastructure and security. Currently, we are simulating the fate of nitrates in the Los Angeles basin from their beginning as nitrate-precursors produced by auto emissions and industrial processes, tracking their dispersion and chemistry as they are transported by regional winds and eventually wet or dry deposit on the ground, tracing their path as they are entrained into surface water runoff during rain events and then carried into the storm water system where dispersion and biologically-mediated chemical reactions take place (fig. 7).

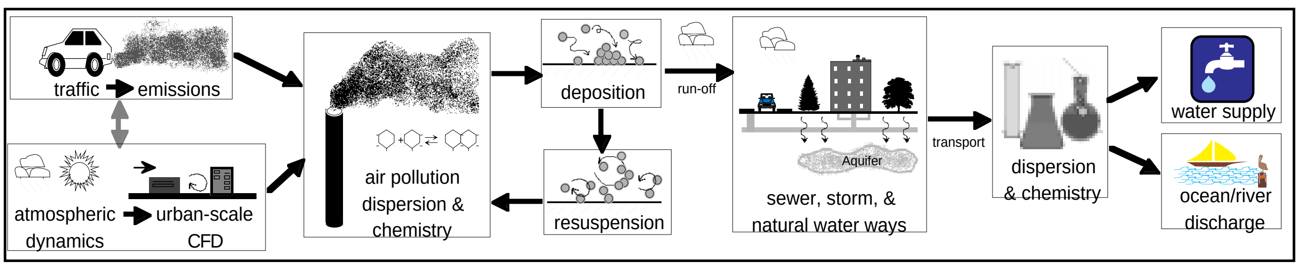


Fig. 7. Nitrate pathway through the transportation, air, and water systems. The proposed modeling system can be applied to many different kinds of air contaminants (e.g., from accidental spills, industrial sources, a CBW attack). The air/water modules could be used in reverse to track vapors emanating from underground sources, as in many EM clean-up projects.

Accomplishments During 1997-1998

The system of linked models for studying the fate of pollutants through air and water pathways is shown in Fig. 8. In short, RAMS and HOTMAC will provide time-dependent 3-D meteorological fields to the CIT air chemistry code for wet and dry season cases, respectively. CIT will then simulate the gas and aerosol phase chemistry and produce wet and dry deposition fields of various pollutants. The deposited pollutants will be input to the SWMM model along with precipitation fields from RAMS. SWMM will compute urban runoff flow amounts and pollutant loading, which will then be utilized by the WASP model to simulate the fate of pollutants in a receiving water body. Our first year efforts have concentrated on running each of the described models, obtaining data sets needed for model input and validation, and linking the models in a crude way in order to follow the pollutants through the complete system. **A short description of each model follows.**

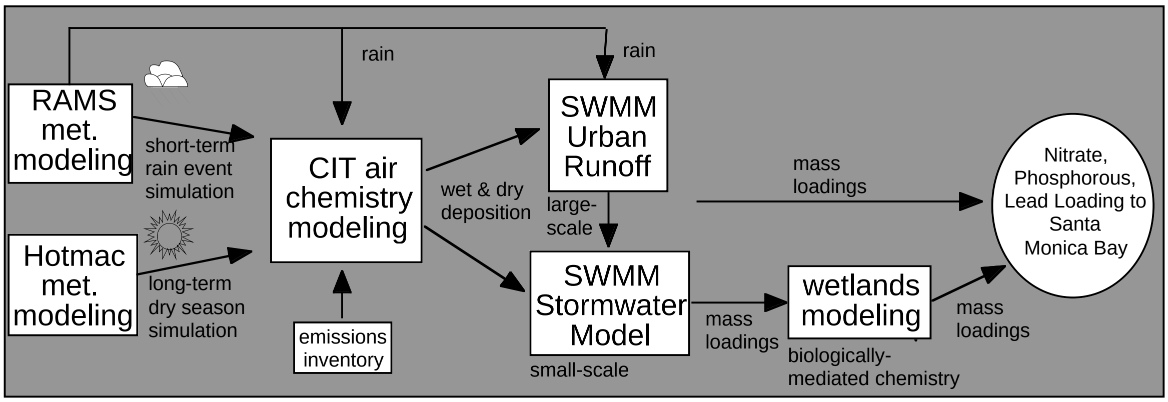


Figure 8. Modeling system for following pollutants through air-water pathways in an urban environment. With some modifications, the fate of pollutants from other sources could be modeled as well, for example accidental releases of toxic agents, heavy metals from brake pads, or noxious vapors from waste

RAMS (Regional Atmospheric Modeling System) and HOTMAC (Higher-Order Turbulence Model for Atmospheric Circulation). RAMS (Pielke et al.., 1992) and HOTMAC (Yamada and Kao, 1986) are both 3-d prognostic mesoscale meteorological models. Employing finite difference schemes, they solve the geophysical fluid dynamics conservation equations for mass, momentum, heat, and moisture, as well as thermal diffusion equations. in the soil, a surface energy budget, and long and shortwave radiative fluxes.

For the wet weather simulations, RAMS will be run in non-hydrostatic mode and account for precipitation using a partial two-moment microphysics scheme which includes eight water species. A nested grid approach using horizontal 80, 20, 5 and 1.25 km grid spacings will be used in order to cover the synoptic scale weather over the Pacific Ocean and Western US and to resolve the region of interest, the LA basin (see Costigan, 1998). For the dry weather simulations, HOTMAC will be run in hydrostatic mode and use an urban canopy parameterization to account for the effect of sub-grid buildings. A 15, 5, and 1.67 km nested grid scheme is being used. The outer-most grid covers the lower 1/3 of California, the intermediate grid matches the CIT air chemistry domain, and the inner-most grid is centered over Santa Monica Bay effects (see Brown, 1998).

CIT (Cal Tech/Carnegie Mellon) Air Chemistry Code. The CIT airshed (chemistry-transport) model (McRae et al.. 1982 and Russell et al.. 1988) is a 3-d Eulerian photochemical model that solves the atmospheric diffusion equation using numerical methods. It uses the LCC (Lurmann, Carter, and Coyner) lumped-molecule chemical mechanism and contains a resistance-based dry deposition module. The CIT model has not been formulated for wet deposition, so we will calculate total deposition of the soluble nitrogen species based on vertically-integrated column mass up to the model top at the time of the rainfall.

CIT will be applied to the Los Angeles basin for calculation of deposition of nitrogen-containing species for two periods during the 1987 Southern California Air Quality Study (SCAQS). The dry season simulation will be for August, 1987 and will use the SCAQS emission inventory and provide dry deposition and inferred buildup for the SWMM urban runoff model. Previously, CIT has been applied to the study of dry deposition of nitrogen species (NO, NO_2, PAN, HNO_3, NH_3, and NH_4NO_3) in the Los Angeles basin for August, 1982 (Russell et al.. 1993). 3-d meteorological fields will be supplied by the HOTMAC code. The wet season simulation will be for an early December, 1987 episode in which high nitrate concentrations were noted. For this episode the RAMS model will be used to provide meteorological fields and precipitation. For both cases, the CIT model will have a single grid mesh with 5km resolution. The modeling domain is centered over the Santa Monica Bay watershed which includes 1,725 km^2 of the Los Angeles basin.

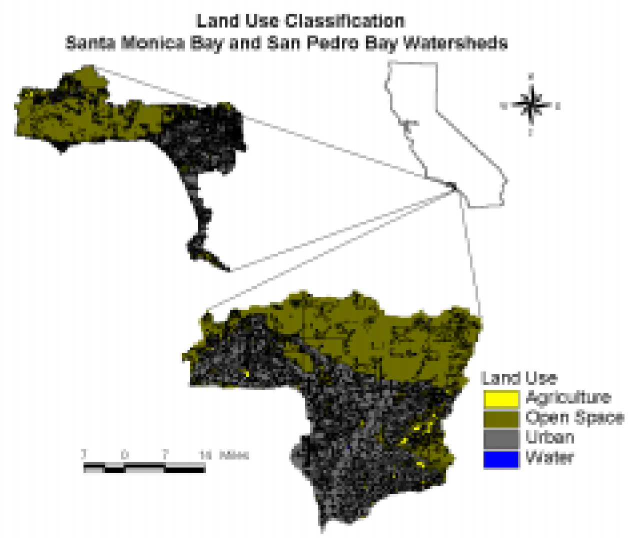


Fig 9. Land Use in Santa Monica Bay and San Pedro Bay Watersheds

SWMM (Storm Water Management Model). For this project, SWMM (Huber and Dickinson 1988) has been selected to simulate the urban watershed and storm-sewer network. SWMM is a large, comprehensive software package capable of simulating the transport of precipitation and pollutants from the ground surface, through pipe/ channel networks and storage/treatment facilities, and finally to receiving-waters. It is freely available from the USEPA.

Operationally SWMM is divided into computational and service "blocks”. This study will use the RUNOFF Block of SWMM to simulate the transport of stormwater runoff and pollutants over the pervious and impervious surfaces of the urban watershed. The RUNOFF Block uses a non-linear reservoir model for calculating runoff and empirically-derived build-up/

washoff curves to estimate pollutant loading. Once the stormwater reaches a specified storm drainage inlet the TRANSPORT Block of SWMM is used to continue the simulation of the transport of runoff and pollutants through the storm drainage network. TRANSPORT uses the kinematic wave approxi-mation (truncated St. Venant eqns.) for computing flow through pipes.

In this initial study, SWMM will operate on the output from a precipitation model (RAMS) and an atmospheric chemistry model (CIT) to drive the urban runoff simulation for a single rainfall event. For the RUNOFF Block, the Santa Monica and San Pedro Bay watersheds need to be divided into sub-catchments. Predominant land-use in each sub-catchment determines the build-up/ washoff expression to use. The TRANSPORT Block requires detailed pipe network information (inlet location, pipe size, slope, roughness). This Block will be used for Ballona, a sub-watershed of Santa Monica Bay. The output from SWMM will be in the form of runoff hydrographs and polluto-graphs describing the time-variable response of the urban area to the precipitation and deposition loading and will then be used as input to the wetlands modeling component.

"The urban research agenda for the 1990's should focus on the identification of innovative approaches to deal with complex issues in urban management and on strengthening national capacities to plan and implement urban development programs"

—G. S. Cheema,
in Mega-City Growth and the Future

WASP (The Water Quality Analysis Simulation Program). WASP5 (Ambrose et al.., 1993) is a receiving water body contaminant fate and transport model. It is a dynamic compartment model utilizing equations based on the conservation of mass to determine the concentrations of chemical constituents from point of input to point of output. It can be applied in one, two, or three dimensions and treats a water body as a series of computational elements. Elements can be surface water, benthic porewater, surface of the benthos, or subsurface of the benthos. Environmental properties and chemical concentrations are considered spatially constant within segments.

The WASP program includes six transport mechanisms: advection and dispersion in the water column, advection and dispersion in the porewater, settling, re-suspension, and sedimentation of solids, and evaporation or precipitation. WASP is often connected to DYNHYD, a hydro-dynamics program which simulates the movement of water. In DYNHYD, the temporal and spatial movements of water are followed using a series of mass balance equations. WASP has two supporting sub-models: TOXI5 and EUTRO5. These models predict dissolved and sorbed chemical concentrations in the sediment and water column and predict the effects of nutrients and organic matter on dissolved oxygen and phytoplankton dynamics. EUTRO simulates the transport and transformation reactions of up to eight state variables within four interacting systems: phyto-plankton kinetics, the phosphorus cycle, the nitrogen cycle and the dissolved oxygen balance. EUTRO solves a mass balance equation adding specific transformation processes for the eight state variables in the water column and benthos. WASP inputs include advective and dispersive transport, boundary concentrations, point and diffuse source waste loads, kinetic parameters, constants and time functions, and initial concentrations. WASP5 does not simulate overland flow which is the main mechanism of non-point source pollution, but can use the output from a nonpoint source model, such as SWMM, as input.

The WASP model will be setup to cover the Ballona Wetland, a coastal saltmarsh and the historic drainage basin for the Ballona sub-watershed of Santa Monica Bay in Los Angeles, California. Pollutant loading and inflow rates will be input from the SWMM model. Tidal information will be necessary for outflow boundary conditions. Several wetlands design criteria will be evaluated in terms of their impact on water quality.

Conclusions. We have described a linked set of models that will be used for studying the transport and fate of pollutants through air and water pathways in an urban environment. Our first step involves manually inputting output from one model to another. Eventually, we will need to consider building models or sub-modules that account for interface physics and feedback mechanisms.

Our ultimate goal for this project is to link together other models of urban infrastructure and natural systems in order to understand the complex interactions of the urban and natural environments. Such a modeling system could be used for urban planning, sustainability studies, and vulnerability assessment.

Activities During 1999

Several issues have arisen due to the urban and cross-disciplinary nature of the problem. Research development is needed within individual models to deal with, for example, size-resolved aerosol chemistry and physics, aqueous phase air chemistry, biological mediation of water chemistry, fine resolution cloud and precipitation modeling, and urban canopy effects on meteorological fields. In addition, since the Santa Monica Bay watershed is not completely urbanized and contains mixed land, SWMM (developed to simulate urbanized areas) will need to be modified to account for non-urban runoff.

In addition, several feedback dynamics and interface issues between models need to be resolved, including the relationship between air chemistry production of secondary aerosols and meteorological production of clouds, the interaction of physical, chemical, and biological components in the nitrogen cycle in water, the fate of particulates after they deposit on the ground, and the relationship between precipitation predictions, runoff amounts, and mass loading values. Finally, data availability and validation issues have arisen, namely that long-term data sets are temporally and spatially sparse, while the relatively dense short-term data sets for air and water quality do not coincide in space and time and are few in number. The lack of water quality data is especially important for SWMM as the washoff algorithms require site-specific calibration data.

Fig. 10. Ballona Creek, Los Angeles; part of the study area for the Urban Runoff team.

We have developed collaborations with leaders in different fields to complement our research efforts, including Carnegie-Mellon and Georgia Tech Universities (size-resolved particulate chemistry modeling), UCLA Dept. of Civil Engineering (runoff modeling and water quality data sets), the LA City Stormwater Bureau and LA County Public Works (stormwater data sets and end-user expertise), the Univ. of Alabama Dept. of Civil Engineering (storm water modeling), and the UCLA School of Public Health (biologically-mediated chemistry). Currently we are supporting five graduate students, two of whom are working at LANL on their Ph.D. dissertations. The team includes members from the EES, TSA, and CST divisions.

Goal for 1999: An integrated model of pollutant transport for the Santa Monica Bay watershed of Los Angeles.

Earthquakes and Urban Infrastructure

Introduction Our goal is to provide a set of science- and technology-based computational tools with real-time feedback for disaster planning, training, and management in time of crisis and long-term recovery.

Coupled analysis tools will dynamically simulate the operation of Los Angeles' inter-linked infra-structures during and following an earthquake. As a first step towards creation of this coupled system, we are simulating a major earthquake's effect on the electrical infrastructure within the Los Angeles basin. This set of tools will have a computer-based, multi-layered Geographic Information System (GIS) database coupled to multiple models such as those for seismic ground response, infrastructure damage assessment, and simulations and analysis of infra-structures operations during emergency response and longer-term recovery.

Accomplishments During 1998 Collaborations between the Los Alamos Urban Security team and the Southern California Earthquake Center have begun to link models of non-linear seismic ground response, earthquake damage models, and infrastructure for the City of Los Angeles. This collaboration was driven by concerns for vulnerability of the highway system by CalTrans and the utilities responsible for infrastructure reliability.

In a January 27-28, 1998 workshop, held in Los Angeles, the approach for linking these models was discussed with the potential end-users; attendees at the workshop included disaster response groups, the City of Los Angeles, the California State Geologist, CalTrans, and the Corps of Engineers. They agreed that the most important outcome of the SCEC/Los Alamos collaboration would be a computer-based, multi-layered Geographic Information System database coupled to multiple models such as those for seismic ground response and transportation.

Realistic predictions of earthquake ground motions and of the damage that results from strong motions requires treatment of the important physical processes that influence the distribution of ground motion amplitudes within the urban setting. In

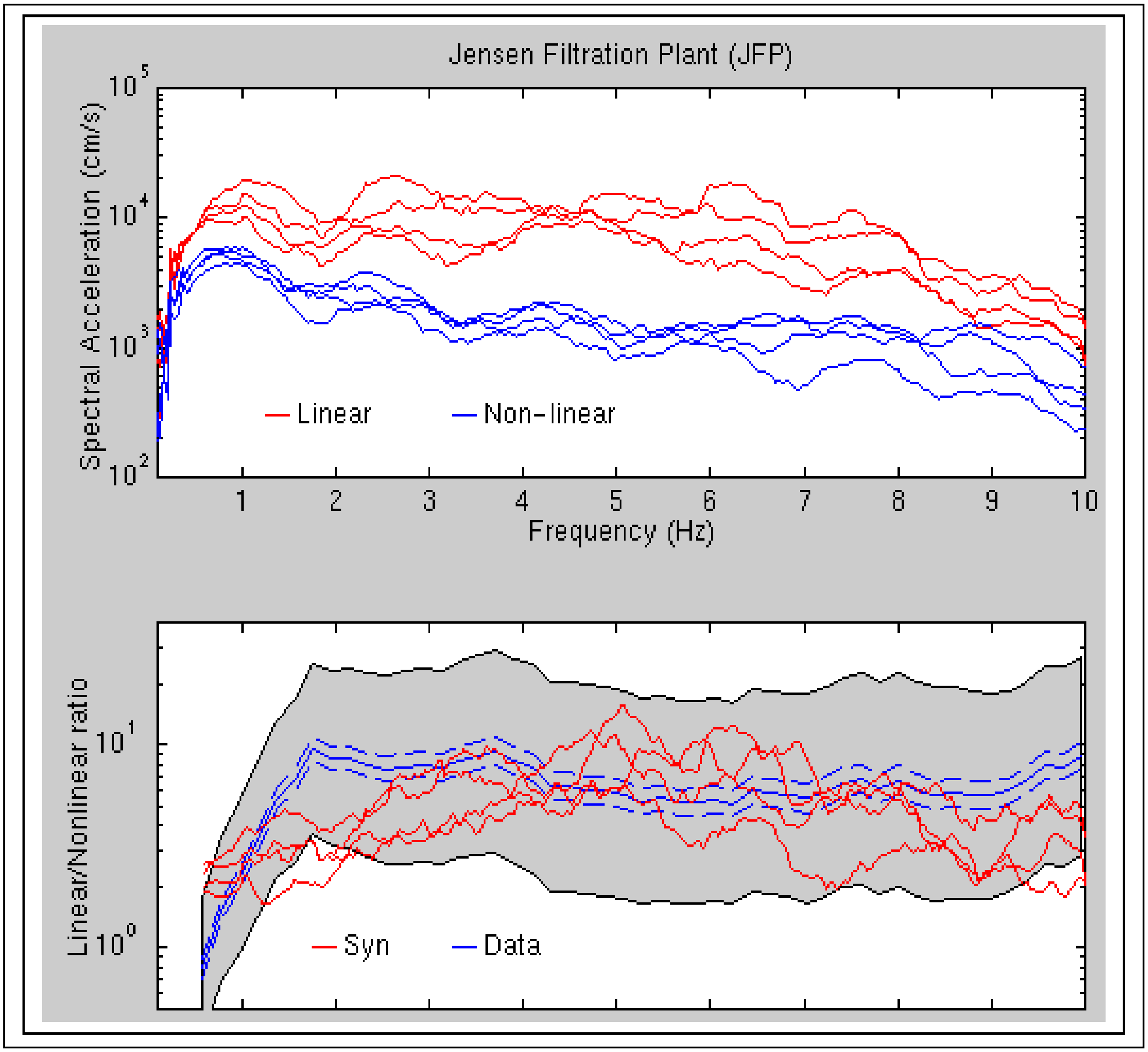


Figure 11. **(Top)** Four realizations of the Northridge earthquake source were used to simulate linear and non-linear ground motions at the Jensen Filtration Plant in the northern part of the Los Angeles basin. At frequencies above about 1 Hz, non-linearity reduces amplitudes by factors of 3 to 10. **(Bottom)** Ratios of the linear-to-non-linear ground motions (gray lines) are compared with data from the Northridge main shock and aftershocks analyzed by Field et al (1997). The broad band represents the range of results derived for numerous soil sites in the LA Basin, the solid curves represents the mean, and the dashed curves indicate one standard deviation. Because the simulations were done for a one-dimensional soil column, for one component of the shear motion, the overall agreement between the simulations and the data is encouraging.

addition to the magnitude, character, and location of the earthquake rupture, important effects include focusing of earthquake energy in sedimentary basins (Olsen et al. 1995), amplification of ground motions due to the presence of low impedance soils (e.g.

Murphy et al. 1971), and de-amplification due to non-linear soil response (e.g. Joyner and Chen 1975). In a study of ground motions recorded during the 1994 Northridge earthquake and its aftershocks, Field et al. (1997) determined that, while low-amplitude 1-Hz aftershock ground motions at soil sites were approximately three times stronger than motions at rock sites, motions produced at soil sites by the main shock were only 1.5 to 2 times stronger than at rock sites. Although a disproportionately high percentage of serious damage to structures during the Northridge main shock occurred at soil sites, neglect of the effects of non-linearity in simulations can result in a significant over-prediction of damage.

In a collaboration between the Los Alamos Urban Security team and Dr. K. B. Olsen at University of California-Santa Barbara, simulations were performed of seismic wave propagation in one-dimensional soil columns using input ground motions at depth from Olsen's three-dimensional Northridge simulations. Use of plausible soil properties produced good comparisons between the soil-column simulations and the Field et al. (1997) Northridge results (Figure 11). In addition, a generalization of the Masing Rule—used to calculated hysteretic stress-strain curves —due to Pyke (1979) was tested in the one-dimensional simulations and is now being implemented in two dimensions. This will be the first numerical treatment of non-linear behavior in seismic wave propagation studies in two dimensions.

In conjunction with the Western States Seismic Policy Council meeting, September 15-18, 1998, SCEC and LANL are hosting a workshop on September 18, 1998 involving representatives from the California Office of Emergency Services, California Division of Mines and Geology, CalTrans, California Energy Commission, City and County of Los Angeles, the utilities, and the Red Cross. Additional collaborators will include PEER, Trinet, and FEMA. The purpose of the workshop is to have end-user input to the models being developed and to seek funding to expand and continue this work after fiscal year 1999.

Activities During 1999 As a first step towards creation of a coupled system, we are modeling the effects of a major earthquake on infrastructure within the Los Angeles basin. This set of tools will have a computer-based, multi-layered GIS database coupled to multiple models such as those for seismic ground response, infrastructure damage assessment, and simulations and analysis of the infrastructure operations during emergency response and longer-term recovery. The tool's multi-layered database will include information on the geology of the area, ground motions for scenario events, a complete catalog of the infrastructure and its structural frailties (e.g., delineation of lifeline routes and nodes such as substations, interchanges; critical facilities such as hospitals, fire and police stations, utilities such as dams and power stations; communications; and selected building stock: classes of buildings and vulnerabilities according to construction type), all socio-economic systems, and regional demographics.

For a given scenario, the simulation system will calculate the 3-D propagation of seismic shock waves and the resultant ground motions. The ground motion predictions will be used to estimate damage to the infrastructure—probabilistically at first, but ultimately stochastic algorithms would select a specific set of damaged infrastructure components and create a specific damaged city environment. Dynamic simulations of the damaged inter-linked infrastructures would then illustrate how the earthquake affects the city’s ability to function. Within this damaged environment, emergency response scenarios would be simulated to rescue and treat injured people and to restore vital services. Various cleanup, restoration, and recovery alternatives would be explored to rapidly return the damaged city to near normal operation. Analyses of longer term rebuilding alternatives would identify those infrastructure investments that would lead to a more robust, sustainable urban system. Results of all these simulations will be displayed with high-quality graphics.

The unique nature of this project is two-fold; the ground response is based on non-linear seismic models and the models require ASCI computing capability at Los Alamos. This first product would be used by contingency planners as a pre-event planning tool; by responders as a real-time event-specific information source and damage assessment tool; and by both planners and responders to model losses, rapidly determine resources needed, and estimate social-economic impacts of both real and simulated events. All groups could use the tool to model and implement plans for urban damage mitigation, recovery, and re-growth.

This simulation is being created in collaboration with the Southern California Earthquake Center and the Pacific Earthquake Engineering Research Center, with advice from California Office of Emergency Services, California Division of Mines and Geology, CalTrans, California Energy Commission, City and County of Los Angeles, the utilities, and the Red Cross.

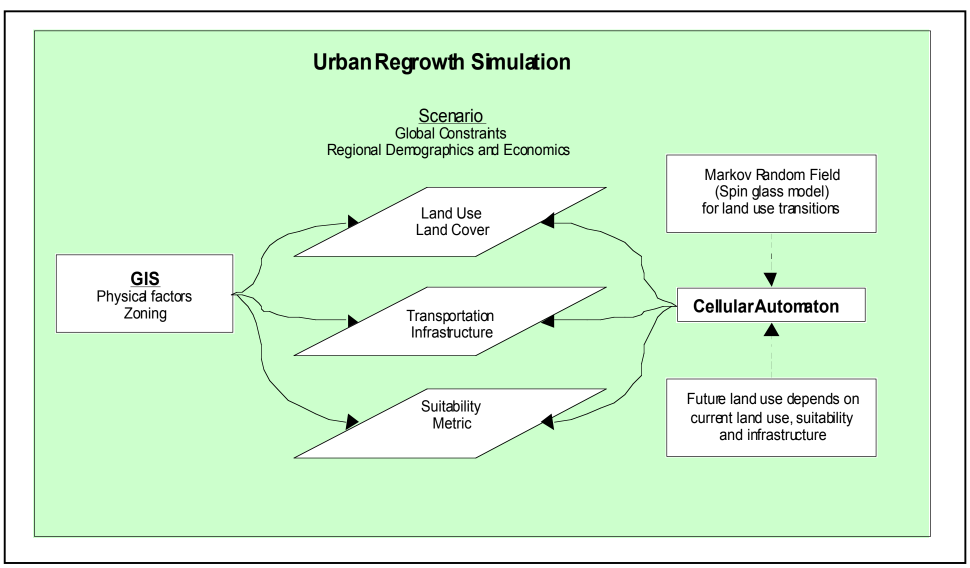
Goal for 1999—Production of a predicted damage state by linking modeled seismic ground response, the HAZUS code, and an infrastructure model for Los Angeles.

City Recovery and Growth—Urban Evolution after a Major Earthquake

Introduction Modeling city recovery and regrowth after a scenario earthquake for Los Angeles will focus on ensuring that an integrated, "systems" approach is involved in our competency. There is a community of people who do this type of modeling of urban dynamics and responses to various planning decisions, for example. A major contribution that we bring to the table is the environmental process-based models with their interactions (between each other and with other components such as economics and demographics).

Accomplishments During 1998 Activities during FY 1998 focused on developing the approach to be used for modeling re-growth of Los Angeles after a major earthquake. The approaches that are being evaluated include:

1. Using Random Markov Field models for evolution of land use in an area partly destroyed by a natural disaster;
2. Developing observations to be used for the comparison of land use dynamics generated in a simulation with real GIS data on land use dynamics. Such measures include fractal dimension, correlation structure, entropy, mutual information and cluster size distribution;
3. Further develop the capability to work with real GIS data in a seamless fashion in connection with models, simulations and web environments.
4. Further develop the concepts for a collective intelligence web environment that supports consensus building for problems that defy understanding at the individual level (cannot be modeled using traditional approaches); and
5. Implement a decision-support and consensus-building web environment that can be used by disaster planners (stake holders) in the Los Angeles case study. This web environment is envisioned as integrating all the major components of the Urban Security project and will be one of the main interfaces between the project and the end users in Los Angeles.



Collaborations were established, with eventual exchange of graduate students and post-doctoral fellows, with the Geography Department at the University of California—Santa Barbara and the Center for Urban Policy Research, Rutgers University.

Activities During 1999 We will simulate the re-growth of part of Los Angeles after it has been damaged by a major earthquake. This will be done by allowing the urban system to self-organize by means of a two-level, cellular-automata-style simulation with external forcing, originally developed by Roger White, University of Newfoundland. The whole system has a two level spatial update dynamics such that the future land use at each location in principle is determined as a function of its current use together with the current land use and local infrastructure access of a smaller area surrounding the current location. However, the actual functionality at this fine grid resolution takes into account regional constraints, such as overall transportation infrastructure access, external economical forcing (planned constructions) and some randomness at a courser level (regional grid).

It should be noted that time series of empirical land use data from many cities world wide show a remarkable universality in urban growth dynamics, which means that a number of crucial observations are similar for e.g. Peking, Rome and Los Angeles.

The simulation takes two different kinds of input, (i) land use data, physical topography, and infrastructure access data from the whole urban area (high resolution) and (ii) regional demographics and regional economical constraints as external forcing functions (low resolution). This involves collection and compilation of land use data etc. from Los Angeles to be used in a modified version by the urban evolution simulation. We should be able to use slightly pre-processed GIS data, to our two levels of resolution, which is then iterated by the simulation and written out at specified intervals. We will probably need a simple graphical interface capability by which we can view the GIS data, both input and output.

The output of the earthquake simulation defines the degree to which the building structures and other infrastructure (roads, rails, etc) are destroyed which then defines the initial conditions for the urban evolution model. We are currently discussing whether we need to modify the current urban evolution simulation to include rules for "clean-up".

This effort is based in part on a new collaboration with the Geography Department at UC Santa Barbara, where a proposal was recently submitted to NSF for “An integrated modeling environment for urban change research.”

Goal During 1999—Model of regrowth of a significant part of Los Angeles after it has been damaged by a major earthquake.

Framework Design

Introduction The purpose of the Urban Security Framework Phase I is to design and implement an integrated modeling system consisting of legacy code components written in different languages, installed on different hardware platforms. One of the premier assets of Los Alamos National Laboratory is its strength in scientific modeling and simulation. However, in the past modeling efforts have been narrow in focus and efforts to link existing codes have been tedious and uncommon. New advances in computational tools have made a more general solution to this problem possible.

“The Delphi Project provides a capability for generating the information needed and the infra-structure necessary for making informed, science-based decisions on questions of national importance.”

—Summary of the Delphi Project—A New Era in Simulation Science

Accomplishments During 1997-1998

The Urban Security Framework was implemented using JAVA and CORBA, an *Object Request Broker* (ORB). This combination allows communication among objects written in different languages across address spaces and networks; it allows for the incorporation of existing legacy code while adhering the following seven design criteria: (1) Extensible, (2) Distributed, (3) Multi-user, (4) Parallel, (5) Secure, (6) User friendly, and (7) Easily implemented. There are many advantages of this design; any code module, existing or newly developed, may be added to the system. Any user with network access may use the system but modules may restrict access for security. Many users can use the system at the same time; legacy codes can run on the most appropriate platform avoiding conversion costs and providing for parallel computation where appropriate; a minimum amount of work is required to add a module to the system.

The Frameworks consists of a setup server, application servers and clients. The end user would access the Frameworks through the client by bringing up a browser (e.g., Netscape) and connecting with the Urban Security WEB page. This screen lists the available system objects (e.g. data base access, grid generation, visualization, and simulation). To run a simulation, a user might first access the setup server and request setup specifications from the run-history database. The user would select the specific simulation, modify the input, and click the 'run' button and the simulation would execute on the remote application server. Upon completion the client may ask the setup server to store this simulation's setup specification and run results in the run-history database or to activate the visualization server or to perform some other action. For examples and more documentation please see: http://www.acl.lanl.gov/~jegeorge/T1/USFramePlans.html.

A summary of the accomplishments including the specifics of both the design and implementation phase follow:

- Proof-of-concept setup server was established for files and input/output specifications.
- Proof-of-concept automatic GUI (Graphical User Interface) was implemented for generation of inputs; editing inputs, sending modified inputs to an application server and running the application on the remote server.
- Implementation of an example application server verified the Frameworks design.
- The design of coupling among the client, setup server, and remote application server was completed.
- Adding and application only requires writing its input specification using the framework grammar and implementing the application server according to the defined frameworks IDL. The setup server and client remain unchanged.

Design Phase:

1. Identified the features of the setup server and the run-history data base.

2. Identified "actions" to be implemented, which include: visualizing data (input and output), executing the application, saving run history into the data base, printing, browsing the run history data base, and checking input specifications.

3. Defined the Frameworks grammar for input

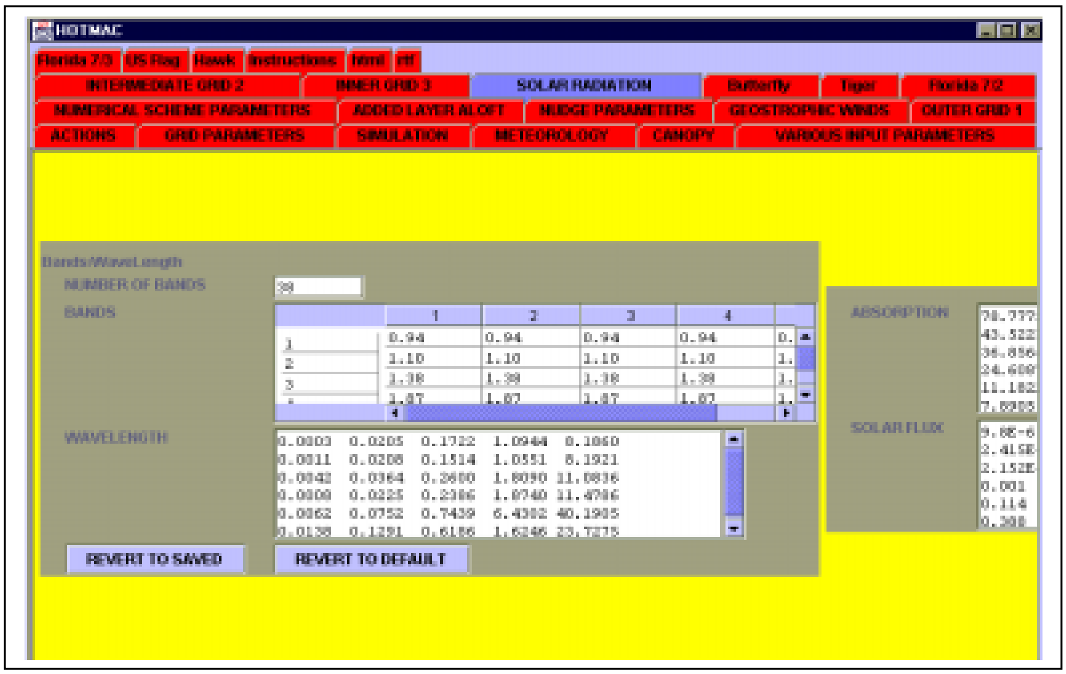


Fig. 13. One of the HOTMAC graphic user interface screens, which shows editable input fields. These screens are generated automatically by the Frameworks system.

specifications to create the Graphic User Interface (GUI).

Implementation Phase:

1. Illustrated the features of the setup server and run history data base with a spread sheet implementation.

2. Wrote the Interface Description Language (IDL) to allow communication across

platforms and languages among client, setup server, and application server.

3. Implemented the prototype client (with several mime-type viewers) and setup server.

4. Chose a sample application (HOTMAC), wrote its input specification in the Frameworks grammar, and implemented the HOTMAC application server.

   After implementing the HOTMAC server, the input specification grammar is added to the setup server, and the user has a complete HOTMAC environment. A "HOTMAC user" selects the desired input specification from the setup server, modifies it, has the HOTMAC server run the application, saves the results into the setup server and views the results with appropriate tools.

Activities During 1999

We will add more modules to the Frameworks. We will implement the run-history database using a commercial database product that supports JAVA Database connections. We will implement security including authentication and policy management (limiting the scope of a user's actions to previously permitted actions). We will investigate visualization of output results and input parameters.

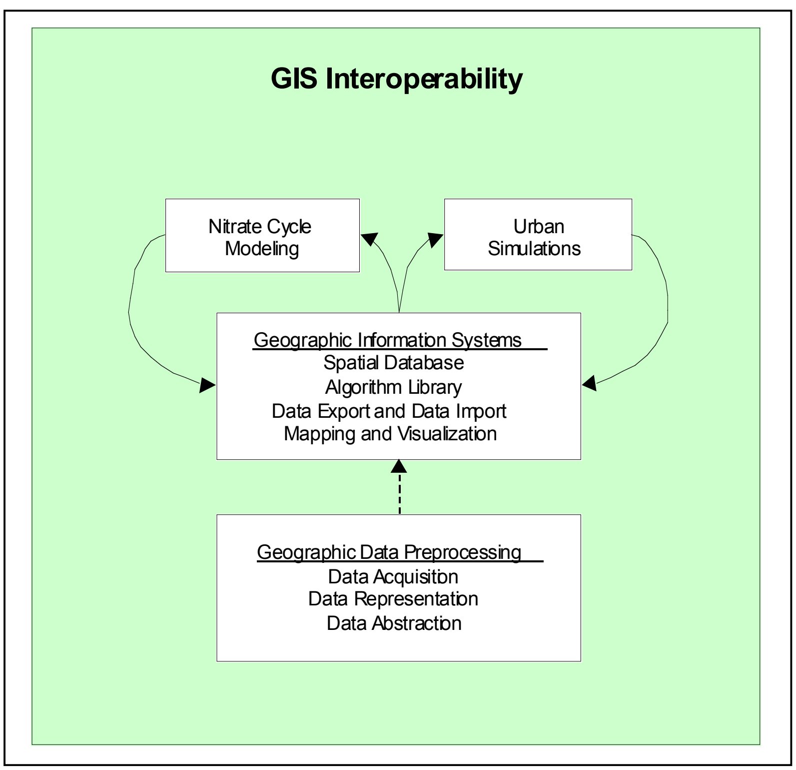
Goal during 1999: A framework that has been used and evaluated by the Urban Air-Water Transport Pathways team.

Geographic Information Systems (GIS)

Introduction The GIS Team provides continued support to the Urban Air-Water Transport Pathways and Earthquakes and Urban Infrastructure teams by gathering, synthesizing and organizing disparate data sources into common databases. Important components of this work include identifying and evaluating data sources for project fitness, preprocessing data for the different modelers and providing technical contributions with respect to spatial processing algorithms and implementations. This work will continue in close collaboration with all of the researchers.

Accomplishments During 1998

The creation of several large databases to support urban stormwater runoff simulations effort was initiated in close cooperation with the modelers in both of these areas. The creation of these spatial databases involved the acquisition of data from disparate data sources, including the USGS and NOAA and post-processing to meet model requirements. Additional data were acquired for the Los Angeles area through our collaborators at UCLA and the Southern California Association of Governments. These data are constantly being staged into databases, depending on modeling requirements such as spatial resolution, land use/land cover categorizations and map projections.



A preliminary architecture for Geographic Information Systems (GIS) Interoperability was identified and the first steps to its eventual implementation were begun. The architecture is consistent with the integrated modeling framework and different components of the Urban Security LDRD-CD. It separates data compilation and pre-processing from the actual modeling of a static representation of the greater Los Angeles area. The architecture addresses GIS technical interoperability, while the data gathering and preprocessing focused on semantics (e.g. different definitions of land use) and institutional issues such as data sharing and partnerships.

The GIS Team evaluated HAZUS (Hazards US), PC-based GIS damage-assessment software, to support earthquake modeling and infrastructure loss estimation methodologies. Another multi-hazard GISystem software package, Consequences Assessment Tool Set (CATS) was deployed and evaluated relative to its damage functions and database. Suitability-to-task specific to seismic risk and impact assessment, as well as data requirements were studied with the goal of integrating LDRD-CD earthquake modeling into HAZUS using expertise in urban planning.

Urban simulations support by the GIS Team involved preparing a database consistent with the earthquake modeling effort to capture salient urban area characteristics for regrowth and forecasting of the urban infrastructure. The preparation of an NSF joint proposal between LANL Urban Security LDRD-CD researchers and faculty at the University of California, Santa Barbara included GIS Team support to address issues such as data fitness, urban structural validation of model results and robust modeling capabilities.

Activities During 1999

The GIS-based computational framework for Urban Security will be further developed addressing issues of interoperability and distributed computing. A loosely-coupled framework will be implemented that provides centralized data processing for providing data to models and incorporating model output into a database for subsequent visualization and presentation of the results. This research component will build upon the advances in geographic information science and the newly developed graphical user interface for the Urban Security LDRD-CD.

Additional collaboration in this next year will be sought on issues of data collection and integration, and modeling in the urban setting from US Geological Survey, National Science Foundation and the Environmental Protection Agency—institutions with urban systems programs. Socioeconomic and planning partners will also be identified to complement the physics-based emphasis of the Urban Security Program.

Goal During 1999: A successful collaboration with the Urban Air-Water Transport Pathways, Framework, and Earthquakes and Infrastructure Teams (all use a GIS base)

Other Accomplishments of the Urban Security Team:

The competency development has involved many interactions with division and program office management at Los Alamos, the Department of Energy, Department of Transportation, Department of Defense, US Geological Survey, EPA, municipalities, states, and scientific professional organizations. This has required considerable oversight of this competency development. Specific collaborations are listed in the CD components above. In addition, this team initiated and is now developing a new effort within the International Association of Geodesy and Geophysics and the International Union of Geological Sciences to press for more work on urban systems; the years 2001-2010 may be declared by these scientific organizations as the “Decade of Science in the Cities.”

Collaboration with the Coupled Environmental Modeling Competency Development Project:

The Rio Grande provides an essential water supply for flora, fauna, and human populace in the southwest US. The city of Albuquerque also depends upon the Rio Grande for its sustainability. The river is an important source of recharge to a shallow aquifer that provides the city water and is a possible resource for the future water needs of the city. The upper portions of the river are primarily fed by snowmelt from winter storms. In contrast, the lower portions of the river accumulate runoff from thunderstorms of the summer monsoon season. The waters of the Rio Grande are impacted by regional climate and could be vulnerable to climate change.

Global climate change may impact local regions in diverse ways. Water resources in the Southwestern US may be particularly vulnerable to climate change. Variation in regional climate and precipitation may alter aquifer recharge and thus impact the water supply for cities and farms. In this research, we studied Albuquerque's water cycle and how it may be affected by changes in the regional climate, as manifested by variations in Rio Grande water levels. To do this, we relied on the use of coupled atmospheric, runoff, and ground water models. Preliminary work on the project has focused on uncoupled simulations of the aquifer beneath Albuquerque and winter precipitation simulations of the upper Rio Grande Basin.

Accomplishments during 1997. In the first phase of this project, we studied the spatial variability of precipitation in the southwest region of the US. We were determining how sensitive model-predicted snowpack was to the horizontal resolution of the model grid spacing. Our simulation results for different horizontal resolutions were compared with observations of daily precipitation obtained from cooperative network sites and SNOTEL data. To examine temporal variability, we carried out model simulations for the months of January 1996, which represents a dry extreme for the upper Rio Grande region, and January 1993, representing a recent wet extreme.

Model Description and Setup The numerical model used to carry out the simulations of the atmospheric circulation is the Regional Atmospheric Modeling System (RAMS) (Pielke et al., 1992). For the simulations in this study, the model was run as non-hydrostatic and included a terrain following vertical coordinate system. Solar and terrestrial radiative processes were parameterized as well as vegetation and soil processes and their influence on surface fluxes, temperature, and moisture. Precipitation processes were parameterized using a partial two-moment microphysics scheme that includes eight water species (see Stalker and Bossert, 1998 for a description).

The simulations required the use of two-way interactive, nested grids. The largest grid is necessary to simulate the synoptic-scale flow features in the region and covers most of the western United States and parts of Canada and Mexico. Horizontal grid spacing on grid 1 is 80 km. Grid 2 contains the states of Utah, Arizona, Colorado, and New Mexico and has a horizontal grid spacing of 20 km. In the simulation, which employs higher horizontal resolution, 5 km grid spacing is used on a third grid. Grid 3 is located over the upper Rio Grande and includes the San Juan, Sangre de Cristo, and Jemez mountain ranges of Southern Colorado and Northern New Mexico.

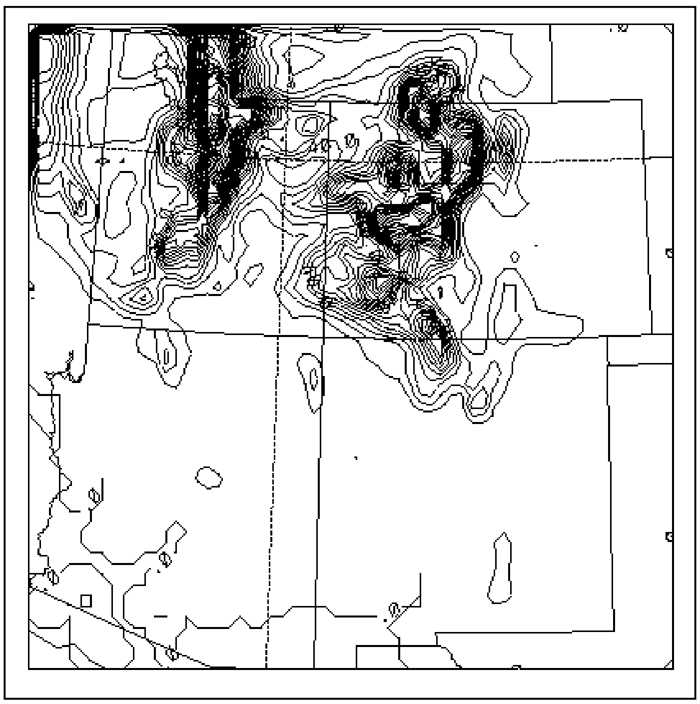


Figure 15. Total accumulated precipitation for January 1996 on grid 2. Contour intervals are approximately 10 mm.

The RAMS simulations were initialized with data derived form the National Centers for Environmental Prediction (NCEP) 2.5 degree gridded analysis. In addition, time-dependent fields were derived from the NCEP data for 4-dimensional data assimilation, where the model solution is nudged toward the observed fields.

Results Figure 15 gives the predicted total precipitation on grid 2 for the time period from 0000 UTC on 1 January 1996 through 1200 UTC on 31 January 1996. This month-long simulation represents a month in the winter of 1995-1996, a dry season in the area. Because of the length of this simulation, only two nested grids were incorporated in this run. The finest horizontal grid spacing in this run was 20 km and precipitation was calculated by a cumulus parameterization scheme. In general, higher precipitation amounts are predicted over higher topography, namely over the San Juan and Sangre de Cristo mountain ranges. Comparisons to the observed accumulated precipitation indicate that the model is doing a pretty good job of predicting the high precipitation areas in the central San Juan Mountains and the Sangre de Cristo Mountains near the Colorado and New Mexico border. However, it is not resolving some of the finer details of the observed precipitation field. In particular, the model underestimates precipitation in the southern Sangre de Cristo Mountains and in the Jemez Mountains.

Another model simulation was then run on a single, three-day precipitation event during this January case. A third high-resolution grid was added to investigate the effects of model resolution on the predicted precipitation field. Figure 16a gives the accumulated total precipitation on grid 2 (20 km resolution) and

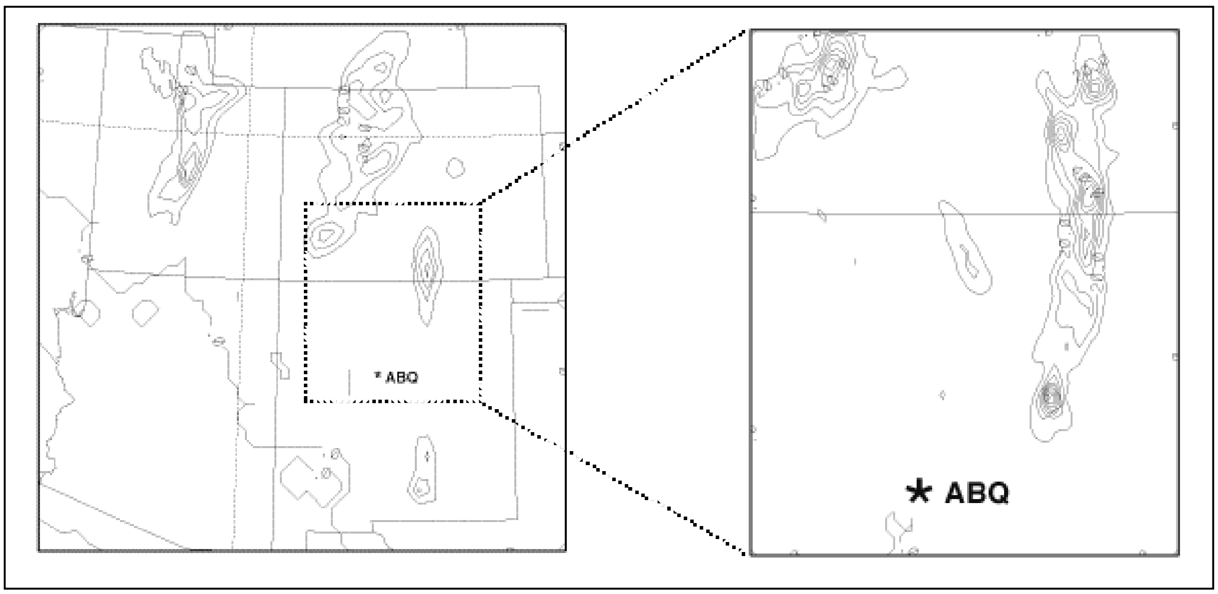


Figure 16. **a)** Total accumulated precipitation for 1-2 January 1996 on grid two (20 km resolution) of two-grid run. Contour interval is ~ 1 mm. **b)** Total accumulated precipitation for 31 Dec 95 - 2 Jan 96 on grid three (5 km resolution) of three-grid run.

Figure 16b shows the accumulated total precipitation on grid 3 (5 km resolution). The most obvious difference between the runs is the much larger precipitation amounts predicted by the high resolution run (note the different contour intervals used in Figures 16 a and b), especially in the Sangre de Cristo Mountains. The low resolution simulation appears to underpredict precipitation totals in these areas while the high resolution simulation overpredicts, but it should be pointed out that the observational data is sparse at the higher elevations.

Continued Work This work is continuing under the Coupled Environmental Modeling program. To examine the temporal variability of the precipitation, this study continued with an additional simulation, at 20 km resolution, for the month of January 1993, which represents a recent wet extreme. The continued work also included the coupling of RAMS with run-off and ground water models. The coupled modeling system will run on the multi-processor computers available at Los Alamos. Running the modeling system on these machines facilitates the use of greater than two interactive nested grids and better horizontal resolution.

The work with RAMS for the Urban Security project has now focussed on the Los Angeles area. We are simulating precipitation over the urban area for input to the SWMM model as part of the "Urban Runoff" task. These simulations also run on the multi-processor nirvana blue machines. We have chosen to simulate a sample case for the precipitation event of 4-5 December 1987, which follows an air pollution event on 3 December (when measured nitrate concentrations were high). The complex interactions of the meso-scale forcings in this urban area with the synoptic-scale weather are being simulated.

Overall plan for the 2-year Urban Security CD

At the end of two years we will be competent in integrating modeling of interacting environmental processes with urban infrastructure data in such a manner that we will be able to address complicated issues of urban vulnerability and sustainability where environment is important.

In this thrust, being "competent" means:

- A demonstrated ability to do original research on key issues where urban infrastructure, vulnerability, and environment are linked.

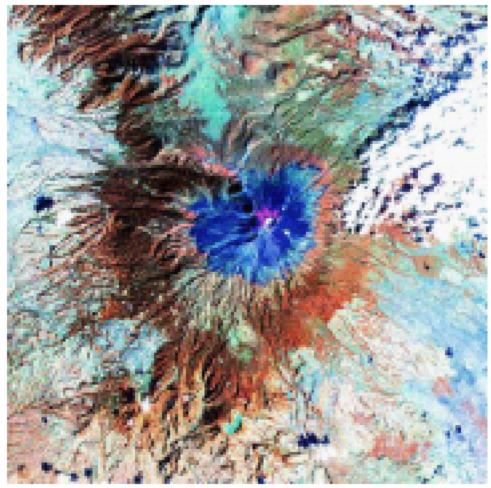
- A demonstrated understanding of the "big picture" of urban issues. This includes physical and chemical processes, civil protection, infrastructure, environment, social, and economic aspects of the cities.

- Recognition among policy makers, urban planners, civil defense officials, and city managers that we have made and can continue to make original interdisciplinary scientific contributions to urban issues. The main focus of our "originality" will lie in the interactions (or interfaces) between various components of urban systems.

- Being valued collaborators with existing urban community and the newer field of civil infrastructure protection.

- Being a driving force in the international urban science community, with an eye toward ensuring that the science is brought into the realm of making a difference in human lives.

- Demonstrated ability to link relevant computer modeling and simulation codes within an integrated framework design.



Satellite image of the volcano Popocatéptl, the potential source of volcanic ashfall that could paralyze the infrastructures of Mexico City. A joint project with the National University (UNAM) addresses the problem of volcanic hazards and urban infrastructure

Concluding Remarks

The Los Alamos Urban Security Team has been charged with developing a laboratory-wide technical competency to approach urban modeling from a multidisciplinary perspective. Over a period of less than two years, our six-division, interdisciplinary team and its outside collaborators have made strong steps toward developing the competency that will lead us toward the tools required for an understanding of the integrated urban systems. This view of cities is mandatory if we are to anticipate and mitigate the vulnerabilities that will affect our security and quality of life. This unique approach is based upon simulation science and the high-performance computing platforms that are required to develop these systems.

Key Project Personnel at Los Alamos

Michael Brown: TSA-4. Ph.D. Atmospheric Sciences. Areas of Interest: Turbulence, Boundary-layer, Plume Dispersion, Urban Canyon, and Mesoscale Meteorological Modeling.

Keeley Costigan: EES-5. PhD., Atmospheric Sciences. Areas of Interest: Numerical simulation with the Regional Atmospheric Modeling System (RAMS) and analysis of complex terrain meteorology, including flow in valleys and air quality studies. Numerical simulation of the large eddies of the atmospheric boundary layer and their interaction with larger scale circulation.

Chuck Farrar, ESA-Div. Ph. D. Structural Engineering; vibration-based damage identification. Seismic analyses of highway structures.

David Fogel PH.D. EES-5. Geographic Information Systems.

Denise George: T-1. MS, Computer Sciences. Areas of Interest: Software System Design, Parallel and Distributed Computing.

Jim George, ACL, Ph.D., Computer Science. Area of Interest: distributed object design.

Robert Greene, EES-5. GIS, Applied mathematics.

Grant Heiken: EES-1. Ph.D., Geology. Areas of Interest: Natural hazards, applied volcanology, urban geology.

Eric Jones: EES-5. Ph.D., Astronomy. Areas of Interest: Seismology, numerical modeling, space. Laboratory Fellow.

David Langley: EES-8. B.S. Mathematics; Graphics, atmospheric processes.

George Niederauer: TSA-10. Ph.D., Nuclear Engineering, Areas of Interest: Computational fluid mechanics, porous media and aerosol modeling, nuclear facility containment issues.

Steen Rasmussen: EES-5. Ph.D., Theoretical Physics. Areas of Interest: Simulation and dynamics of self-organizing processes.

Fred Roach, TSA-4. Energy and environmental modeling and applied policy analysis

Belinda Scheber, EES-5. GIS.

La Ron Smith: TSA-DO/SA. PhD. Nuclear Engineering. Areas of Interest: complex systems, risk management, transportation simulation.

Gerald Streit. TSA-4. Air quality and chemical mechanism modeling.

Jake Turin: CST-7. Ph.D., Hydrology. Areas of Interest: Vadose-zone hydrology, subsurface contaminant transport, groundwater geochemistry, and karst hydrology.

Greg Valentine: EES-5. Ph.D., Geology. Areas of Interest: Transport processes in geologic media, plumes, convection, magma dynamics, flow in porous media, explosive volcanism, high-speed multi-phase flows, computational fluid dynamics, hydrothermal systems, planetary processes.

Andrew Wolfsberg: EES-5, Ph.D, Geochemistry. Areas of Interest: Transport and chemical processes in geologic media.

Post-Doctoral Fellows and Graduate Students

Steve Burian, University of Alabama. Storm water modeling, civil engineering (GRA).

Andy Lee, UCLA, civil engineering, urban runoff modeling (GRA)

Laurie McNair, Atmospheric chemistry, ocean modeling (Post-Doc).

Tim McPherson, UCLA, environmental engineering, biology, (GRA).

James Stalker, University of Alabama—Huntsville, atmospheric modeling (Post-Doc).

Sudha Mahashwari, Rutgers University, urban planning and natural disasters (GRA).

Collaborators

Donald Duke, UCLA—Environmental Science and Engineering, School of Public Health, chemistry of stormwater runoff

Renato Funiciello—Universita di Roma-III, Italy, Urban Geology Group.

Tom Henyey, Directory, Southern California Earthquake Center (University of Southern California)

Kim Olsen, UC-Santa Barbara—Institute of Crustal Studies

Giovanni Orsi—Osservatorio Vesuviano, Napoli, Italy, Volcanoes in Cities

Spyros Pandis, Carnegie Mellon, Air Chemistry.

Ted Russell – Georgia Inst. of Technology, Air Chemistry.

Claus Siebe—Universidad Nacional Autonoma de México—Instituto de Geofisica, Volcanic ash fallout and the effects on the infrastructure of Mexico City.

Uri Shamir— Israel Institute of Technology , water and megacities

Michael Stenstrom— UC-Los Angeles, Civil and Environmental Engineering.

Mel Suffet – UC-Los Angeles, Environmental Engineering and Chemistry.

Wing Tam, LA County Storm Water Bureau, storm water runoff in Los Angeles

Roger White—Memorial University, St. Johns, Newfoundland, Modeling City Growth

Lyna Wiggins— Rutgers University—Center for Urban Policy Research, Urban Development, GIS

Professional Meetings and Workshops

September 23-25, 1997. DOE-FEMA Meeting on "Technical Partnerships for Emergency Management," Richland Washington (Mynard and Bossert)

January 20, 1998. Los Alamos Science and Technological Base Programs Review of "Urban Security." (All team members)

January 27-28, 1998. “Earthquakes and Urban Infrastructure—A Workshop.” Los Angeles, CA (Co-sponsored by the Southern California Earthquake Center and the Los Alamos National Laboratory) (Jones, Olsen, Bradley, Farrar, Smith, Heiken, and Valentine)

April 14-15, 1998. “UC Conference on Risk Assessment and Management.” Sacramento, CA. (Heiken)

May 4-6, 1998, DOD Environmental Security Conference, Alexandria, VA. (Brown)

UCGIS (UCGIS: University Consortium for Geographic Information Science) Annual Assembly. Park City, Utah, June 25-28, 1998. (Fogel)

June 27-July 7, 1998. “Cities on Volcanoes.” Roma and Napoli, Italy. (Valentine and Heiken)

July 10-July 18, 1998, General Assembly, International Association of Volcanology and Chemistry of the Earth’s Interior, Cape Town, South Africa (Valentine)

Jul. 21, 1998, National Defense University, 21st Century Emerging Information Technology, Arlington, VA (Brown, Morgeson)

Aug. 25-27 DOD/DOE Urban Hazard Modeling Workshop, McLean, VA. (Brown)

Speakers at Team Meetings:

Donna Smith, Los Alamos CIT-IS, “Functions of the Civilian and Industrial Technology Office.” February 3, 1998.

Grant Heiken, Bob Greene, and Belinda Scheber, EES-1 and 5, “Mexico City—Volcanoes and Infrastructure.” March 3, 1998.

Mike Stenstrom, UCLA, “Storm-Water Management in Los Angeles (SWMM Program), April, 1998.

Dennis Hjeresen, Los Alamos EM-PD, “Status of the Environmental Security program.” April 7, 1998.

Larry Winter, Los Alamos EES-5, “Review of the Coupled Environmental Modeling CD Thrust.” April 7, 1998.

Ray Gordon, Los Alamos TSA-4, “Status of Critical Infrastructure Protection.” June 2, 1998.

Tim McPherson, Los Alamos CST-7, “Nitrogen Chemistry in Storm Drain Systems.” June 2, 1998.

Sudha Maheshwari, Rutgers University, “HAZUS Demonstration and Critique.” June 9, 1998.

Darrell Morgeson, Los Alamos TSA-DO-SA, “National Defense University.” June 2, 1998.

Amanda Cundy, Montana State University and Los Alamos-ESA, “Discussion of HAZUS applications.” August 4, 1998.

Greg Valentine, Los Alamos EES-5, “Damage to structures by explosive volcanic eruptions as inferred from nuclear weapons tests.” August 4, 1998.

Grant Heiken, Los Alamos EES-1, “Tuffs and urban needs.” August 4, 1998.

Steven Burian, University of Alabama and Los Alamos TSA-4. “Fate and transport in urban storm water systems.” August 4, 1998.

PUBLICATIONS AND ABSTRACTS IN FISCAL YEAR 1998

Brown, M. and M. Williams (1998) Urban canopy parameterizations for use in mesoscale meteorological models, 2nd AMS Urb. Env. Conf., Albuquerque, NM.

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